

5-C-17



**TYPE PG-23
PULSE GENERATOR**

**OPERATING
AND
SERVICE MANUAL**

LYONS INSTRUMENTS

C6-84-029



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5-C-17

OPERATING AND SERVICING MANUAL

TYPE PG-21

TYPE PG-23

PULSE GENERATORS

PG. ²³..... Serial No: ⁸⁰⁴⁹.....

Designed and manufactured in England by:

LYONS INSTRUMENTS LIMITED
HODDESDON, HERTS.

Telephone: Hoddesdon 67161

Telex 22724

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ORIGINAL ARTICLES

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Introduction

- Section 1. Specifications
2. General Description
3. Description of Controls
4. Operation
5. Functional Verification
6. Circuit Description
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INTRODUCTION

- (1). Lyons Instruments types PG-21 and PG-23 Pulse Generators are medium speed general purpose instruments intended for laboratory and production use, and providing wide range control of pulse parameters.
- (2). The generators use silicon transistors throughout and have the same wide selection of input triggering, gating and synchronising facilities as is available on all the Lyons Instruments Pulse Generators.
- (3). Although the functions of the various controls are largely self explanatory, to obtain optimum use from the generator the user is recommended to read the Instruction Manual carefully. This manual contains Specifications, Operating Instructions, Circuit Diagrams and Component Layout Diagrams to aid the user in any maintenance or repair work that may be necessary but should any queries arise not covered by this manual please contact Lyons Instruments or their Agents.
- (4). When using the manual the reader is reminded that the PG-23 is a dual output version of the PG-21 and the electronic circuits are essentially the same. Specific differences are mentioned in the text and circuit diagrams are supplied.
- (5). Lyons Instruments products are subject to a one year warranty details of which are given in Section (7) of this manual

APPENDIX

- (1) The first part of the report is devoted to a description of the work done during the year 1954. It is divided into two main sections: (a) the work done in the field, and (b) the work done in the laboratory.
- (2) The second part of the report is devoted to a description of the work done during the year 1955. It is divided into two main sections: (a) the work done in the field, and (b) the work done in the laboratory.
- (3) The third part of the report is devoted to a description of the work done during the year 1956. It is divided into two main sections: (a) the work done in the field, and (b) the work done in the laboratory.
- (4) The fourth part of the report is devoted to a description of the work done during the year 1957. It is divided into two main sections: (a) the work done in the field, and (b) the work done in the laboratory.
- (5) The fifth part of the report is devoted to a description of the work done during the year 1958. It is divided into two main sections: (a) the work done in the field, and (b) the work done in the laboratory.

Section 1

SPECIFICATION

- | | | |
|------|------------------|--|
| 1.1. | Pulse Amplitude | 10V into 50 ohms, variable to 100mV in 10db steps plus a 10db vernier control. Output short circuit and open circuit protected. Duty cycle up to 100% obtainable. |
| 1.2. | Polarity - PG-21 | Positive or negative, switch selected. |
| 1.3. | Polarity - PG-23 | Positive and negative, from two output sockets, with respect to ground. Independent attenuators and normal/complement selection. |
| 1.4. | Shape | Rise time less than 5 ns.
Fall time less than 5 ns.
when terminated in 50Ω.
Overshoot and ringing less than 5% above 300mV.

NOTE: 1.1. and 1.4. apply only when outputs terminated with 50 ohms via cable of that impedance. |
| 1.5. | Pulse Width | Variable from 20ns to 200ms in seven ranges plus vernier control. Jitter less than 0.1% of width +0.3ns. |
| 1.6. | Duty Cycle | Typically greater than 70% direct, and up to 100% using the normal/complement switch. |
| 1.7. | Delay | Variable from -10ns to +200ms in seven ranges plus vernier control. Jitter less than 0.1% of delay +0.3ns. |
| 1.8. | Sync Pulse | At clock rate, positive 3V EMF (1.5V into 50 ohms), width variable from 15ns to 90ns, typical. Rise time 5ns nominal. |
| 1.9. | Repetition Rate | 1Hz to 10MHz in 7 decade ranges plus vernier.
Jitter less than 0.1% of period +0.3ns. |

Introduction

1. The Problem

The first part of the paper is devoted to a discussion of the problem. It is shown that the problem is of great importance and that it has not been solved before.

In the second part of the paper, we shall see that the problem is of great importance and that it has not been solved before.

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In the eighth part of the paper, we shall see that the problem is of great importance and that it has not been solved before.

The ninth part of the paper is devoted to a discussion of the problem. It is shown that the problem is of great importance and that it has not been solved before.

1.10. Pulse Modes

- 1.10.1. Normal Output pulse width and delay controlled in conventional manner.
- 1.10.2. Complement Output inverted but not shifted with respect to ground. Operation of width control reversed.
- 1.10.3. Single Pulse One output appearing at each output per repetition rate cycle.
- 1.10.4. Double Pulse Output pulses occurring in pairs, one pulse at a fixed delay with respect to the sync pulse, the second pulse variable in delay by means of Delay controls.
- 1.10.5. Square Wave Output pulses at clock rate, symmetry adjustable $\pm 7\%$ giving square waves. Width and Delay circuits inoperative.

1.11. External Inputs

All external positions have a sensitivity of 1V maximum variable to 2V on type PG-21 by the sensitivity control (S) and fixed at 1 volt on type PG-23. The threshold level may be adjusted $\pm 2V$ by a front panel preset control (T) and input slope may be positive or negative with respect to 0 volts as determined by the slope switch. Input impedance is $1K\Omega$ 27pf approx. under all external input conditions.

1.11.1. External/
Single Shot

The generator may be externally triggered by a 1V signal from D.C. to 10MHz. A button is provided for single shot operation in this mode.

1.11.2. Gate

The generator may be eynchronously gated by a 1V signal from D.C. to 10MHz.

1.11.3. Sync

The generator may be synchronised to an external signal of 1V if the external signal is within a frequency ratio of 100:1 to the internal clock setting. The pull in range is 10% total.

1.12.	Power Requirements	240V or 220V $\pm 10\%$, 47-65 Hz, 120VA. 115V special order
1.13.	Temperature Ranges	
1.13.1.		Operating 0 - $+50^{\circ}\text{C}$.
1.13.2.		Storage -10° - $+65^{\circ}\text{C}$.
1.14.	Humidity Range	Up to 70% R.H.
1.15.	Dimensions	Height $3\frac{1}{2}"$, width 15", depth 14" overall. (90 x 380 x 355 mm), approx.
1.16.	Net Weight	17.5 lbs. (7.9 kg) approx.
1.17.	Accessories Supplied	Two cables 3 ft. BNC male - BNC male.
1.18.	Rack Mounting	Rack adaptors (19" x $3\frac{1}{2}"$ panel size), available on request (no charge).

SECTION 2

GENERAL DESCRIPTION

A block schematic showing the main circuitry contained within the pulse generator in functional form is shown in FIG. 7.1. All the transistor circuitry is mounted on printed circuit boards with the connections between the boards and the front panel shown. The board layout diagrams will enable a pin connection or component to be readily identified. These layout diagrams show the component positions viewed from the track side of the printed circuit boards.

The main control which determines the operating mode of the instrument is designated GATE, SYNC, AND EXT. The normal operating position is the SYNC position which permits the frequency determining circuitry to operate and produce an output from the rate generator board. In this position the frequency is determined by the concentric coarse-fine controls designated FREQUENCY and located on the front panel. An input via the BNC socket marked INPUT is amplified and differentiated and can be used to synchronise the astable multivibrator with the external signal over a relative frequency range of 100:1. The multivibrator will be pulled into synchronisation if the external input occurs in a time which is up to 10% of the normal unsynchronised period of the rate generator in front of the normal switching time. The input sensitivity is set to 1V and the threshold level may be varied to $\pm 2V$ by adjustment of the control marked T.

When the function selector is placed in the GATE position, the internal oscillator can be turned on and off by a signal derived from the external input. The input signal is a gating OFF signal i.e. when the SLOPE switch is in the +ve position, a level of +1V at the input will turn the rate generator OFF and a level of less than +1V will turn it on again (the voltage levels referred to are relative to the level set by the threshold control). Thus it may be switched on or off with no EXT input applied by suitable adjustment of the threshold and using the slope switch. If the slope is in the positive position and the threshold is set to greater than +1V the rate generator will be off and a negative going input will turn it on thus giving a gating ON mode of operation. The GATE mode is synchronous, that is when the generator is turned on, the first pulse will occur coincident with the switching edge and will be a normal width pulse and likewise if the input signal switches off during a pulse, that pulse will continue to its normal width.

When the function selector is placed in the EXT condition the external input circuits are connected directly to the pulse forming networks and the internal rate generator is inhibited, thus the rate is controlled by the external signal applied. The slope switch in this mode determines whether the output pulse is coincident with the rising or falling edge of the input signal.

In the EXT position, the manual push button produces a single pulse when depressed if the slope switch is in the +ve position. When the function selector is in the SYNC position the output of the rate generator is fed to the width/delay board where it activates both the delay monostable and the sync output monostable. The SYNC output may be varied in width over a range of 15ns to 90ns using the SYNC WIDTH control. The sync width monostable output is then fed to the sync output circuitry which provides a positive going 1.5V sync pulse.

The delay monostable period is set by the concentric coarse-fine controls on the front panel marked DELAY. The lagging edge of the delay monostable is shaped and used to trigger the width monostable, the width being set by the coarse-fine controls on the front panel marked WIDTH. The width monostable may also be triggered by the pulse out of the rate generator board directly when the DP-DELAY or SP/DP switch is in the DP position. Under these conditions, in double pulse mode, the width monostable is triggered twice, once at the start of the delay period and once at the finish. This gives two pulses of equal width at the output, one delayed upon the other by the time set by the DELAY controls, provided that the delay setting for the delay generator is greater than the width setting of the width generator.

In the SQUARE WAVE mode the width and delay circuits are inoperative and the output stages are driven directly from the rate generator. The SYM. ADJUST control permits adjustment of the mark/space ratio over $\pm 7\%$.

The output of the width generator is then fed to the two output amplifiers giving one positive and one negative channel simultaneously. The width monostable will give a duty cycle of up to 80% but if higher duty cycles are required it can be obtained by switching the NORMAL/COMPLEMENT switch to complement and reducing the pulse width setting*.

* In the PG-21 the POLARITY switch selects either the positive or negative channel and connects it to the output socket via a passive attenuator giving 4 switched ranges and vernier: in the PG-23 each channel is provided with its own attenuator, output socket, and NORMAL/COMPLEMENT switch.

SECTION 3

DESCRIPTION OF CONTROLS

3.1. WARNING

Although the output stages of the pulse generator are fully protected against short circuits or open circuits at the output socket, considerable damage can result from feeding excessive power back into the output stages.

Do not directly connect the outputs of the generator to other outputs or voltage sources. Refer to section 4 for notes on operation and output connections.

3.2. CONTROL SETTINGS

The wide range of control of the width, delay and frequency functions means that it is possible to set the controls in a non-compatible manner, for example the pulse width may be set such that it exceeds the period of the clock frequency. In this instance the clock frequency will be divided down and a lower frequency obtained than was expected. With excessive delay switched in a similar result will be obtained which may lead to some confusion in obtaining the required output pulse. To avoid this it is generally advisable to switch to the minimum delay and the minimum viewable pulse width whilst setting up the required frequency, then set the width controls to the desired width of output pulse, finally setting the delay controls.

A brief description of each control and its operation is given followed by a functional verification section which will help the user to become familiar with the instrument.

3.3. POWER SWITCH

The power switch connects A.C. mains to the mains transformer and cooling fan via the mains fuse located on the rear of the instrument. The pilot lamp is lit when this switch is turned on in the upward direction.

3.4. FREQUENCY

The rotary seven position switch selects the required frequency range. The concentric vernier control provides continuously variable settings for all ranges, with some overlap on the top and bottom of each range. Full clockwise rotation of the vernier control sets the highest frequency of each range.

THE HISTORY OF THE
CITY OF BOSTON

FROM THE FIRST SETTLEMENT TO THE PRESENT TIME
BY SAMUEL JOHNSON

VOLUME I
FROM THE FIRST SETTLEMENT TO 1630

THE CITY OF BOSTON WAS FIRST SETTLED BY A COMPANY OF ENGLISHMEN IN 1630. THE FIRST SETTLERS WERE LEAD BY JOHN JOHNSON, WHO HAD BEEN A MEMBER OF THE FIRST ENGLISH SETTLEMENT IN VIRGINIA. HE HAD BEEN IN THE SERVICE OF THE ROYAL NAVY, AND HAD GAINED A REPUTATION AS A CAPTAIN. HE HAD ALSO BEEN A MEMBER OF THE FIRST ENGLISH SETTLEMENT IN VIRGINIA, AND HAD GAINED A REPUTATION AS A CAPTAIN. HE HAD ALSO BEEN A MEMBER OF THE FIRST ENGLISH SETTLEMENT IN VIRGINIA, AND HAD GAINED A REPUTATION AS A CAPTAIN.

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3.4.1.

GATE/SYNC/EXT - SLOPE - THRESHOLD

The three position lever switch selects the mode of operation of the rate generator. The various functions are driven via the EXT input socket and the appropriate function will be operated by either the negative or positive going edge of the input by use of the SLOPE switch.

- a). GATE. In this position an external signal will synchronously gate the rate generator, i.e. the output train will always start at the beginning and finish at the end of a complete normal width pulse.
- b). SYNC. In this position the rate generator may be synchronised to an external source with a frequency ratio to the internal clock of up to 1:100.
- c). EXT. This position enables the generator to be externally triggered up to the maximum rate of the generator clock, or to be manually triggered using the single shot button provided.

The trigger point may be set between plus and minus 2V by means of the threshold potentiometer marked T.

The sensitivity of the EXT input is set to 1V in the PG-23 whilst a sensitivity control potentiometer, marked S, is fitted in the PG-21 where it allows variation of input sensitivity from 1 to 2 volts.

3.5. DELAY

The DELAY rotary switch selects the appropriate one of the seven delay ranges and the concentric vernier provides continuously variable settings for all ranges with some overlap on the top and bottom of each range. Full clockwise rotation of the vernier control sets the MINIMUM delay for each range.

Delay is with respect to the SYNC output pulse leading edge.

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- 3.6. WIDTH The WIDTH rotary switch and vernier operate in the same way as the DELAY controls, full clockwise rotation of the vernier control providing the MINIMUM width for each range.
- 3.7. DP/DELAY (SP)
- 3.7.1. SINGLE PULSE
- Single or double pulse operation is selected by this switch. In the DELAY (SP) position one pulse per cycle occurs at the output, delayed from the SYNC output by a time interval set by the delay control. The delay range has a negative minimum limit with respect to the sync. pulse.
- 3.7.2. DOUBLE PULSE
- The DP position selects the double pulse mode which allows an effective output pulse rate of 20MHz to be obtained by producing two output pulses during every clock period, the time relation of the second to the trigger pulse being set by the DELAY control. The width of both pulses is variable by means of the WIDTH control.
- 3.8. SQUARE WAVE.
- This function is provided on both the PG-21 and PG-23 where it is associated with the NORMAL/COMPLEMENT or SP/DP switches respectively. In the SQ.WAVE condition the width and delay controls are inoperative and the output is in the form of a square wave. Symmetry is adjustable at the front panel (SYM. ADJ).
- 3.9. NORMAL/COMPLEMENT
- In the COMPLEMENT condition a logic inverted output is provided, i.e. the ground reference is retained but the MARK/SPACE relationship is interchanged. Thus in the NORMAL mode, operation of the WIDTH control is as described in 3.6. In the COMPLEMENT mode, the effect of the WIDTH control is reversed, allowing very large duty cycles to be obtained.

- 3.10. AMPLITUDE Amplitude control is by a passive attenuator system. In the PG-23 there are two amplitude controls, one controlling the NEGATIVE channel and the other the POSITIVE. The control has four ranges giving coarse attenuation in 10db steps and a vernier control which allows continuous variation of the output in each range. Full clockwise rotation of the vernier gives full output in each case. The settings are only valid when the generator is terminated in 50 ohms.
- 3.11. POLARITY This rotary switch allows the user to
 (PG-21 only) select positive or negative going pulses with respect to 0 volts.
- 3.12. SYNC & SYNC WIDTH This BNC socket supplies a reference trigger at the internal clock rate (or external input rate). The trigger pulse may be varied between 15ns and 90ns in width using the SYNC WIDTH control. The amplitude of the trigger is 1.5V positive when terminated in 50Ω.

SECTION 4

OPERATION

4.1. IDLE OUTPUT (PG-23 only).

When only one output is being used, radiation from the other may cause ringing of the output in use. This can be conveniently avoided by reducing the amplitude of the idle output by means of its attenuator switch so that it is terminated by the impedance of the attenuator.

4.2. OUTPUT TERMINATION.

To get clean waveshapes with fast transition times, both the interconnecting cables and the load termination must have an impedance of 50 ohms. The termination should be placed at the far end of the cable rather than at the instrument end. Terminating at the pulse generator or using co-axial cable of the wrong characteristic impedance or using clip leads will have detrimental effects on pulse shape and transition times.

4.3. NONLINEAR LOADS

Operating directly into nonlinear devices such as transistors and diodes that exhibit varying impedances in opposite directions causes waveform distortion. This can be prevented by terminating the pulse generator in a network that reflects uniform loading in both directions. A suggested method of driving the base of a transistor is to provide a stand off resistor in series with the base, a bias return resistor and a termination, the three values being adjusted to provide a 50 ohm termination for the pulse generator.

4.4. REACTIVE LOADS

Such loads connected directly to the output will cause pulse distortion. Inductive loads may damage the instrument. The instrument should be protected against inverse voltages generated by energy stored in an inductor or transformer. Diodes should be used to dampen the inverse swings and prevent the output transistors from being exposed to voltages above their inverse ratings.

4.5. DUTY CYCLE

If high duty cycles are required, use may be made of the COMPLEMENT facility of the instrument which reverses the effect of the width controls and allows the width circuits to operate at short recovery times.

Same polarity outputs may be diode mixed and opposite polarity outputs may be resistor mixed, but units may not be directly coupled together nor connected to loads at other than ground potential. Pulse amplitude reduction is substantial for resistor mixing but negligible for diode mixing.

The loading circuit may protect outputs from same polarity voltages above the emitter base breakdown of the output transistors (5 volts). Diodes provide the best protection. Resistors may be used as voltage dividers but should be chosen so that each output is terminated in 50 ohms.

Connections for mixing two outputs may be made by using one of the LI range of accessories.

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SECTION 5
FUNCTIONAL VERIFICATION

5.1.

WARNING.

The instrument is intended for driving resistive loads at ground potential. If any other type of connection is required, please refer to Section 4 and so avoid possible damage to the output circuits.

5.2.

This section of the manual is intended to help the user during "first time" operation of the instrument both in checking that no transit damage has occurred and in becoming familiar with the action of the front panel controls. A general purpose oscilloscope of vertical bandwidth greater than 15MHz and having external trigger and vertical signal delay facilities is necessary, together with leads and suitable terminations.

5.3.

TEST CONNECTIONS AND SETTINGS

5.3.1.

Connect the OUTPUT socket(s) via 50 ohms cable to tee-connector(s), and termination(s) at the oscilloscope vertical inputs.

5.3.2.

Connect SYNC OUT via 50 ohm cable and terminated tee-connector to the external trigger socket of the oscilloscope.

5.3.3.

Connection power cable to mains supply:

LIVE	- RED OR BROWN
NEUTRAL	- BLACK OR BLUE
EARTH	- GREEN OR YELLOW/GREEN.

5.3.4.

Set the instrument controls as follows:

POWER	OFF
FREQUENCY	100K-1M
Vernier	Clockwise
DELAY	0-0.2 μ s
Vernier	Clockwise
WIDTH	0.2 - 0.02 μ s
Vernier	Midway
GATE/SYNC/EXT	SYNC
DP/DELAY/(SP)	DELAY(SP)
NORMAL/COMPLEMENT	NORMAL
AMPLITUDE	10-0db
Vernier	Midway
POLARITY (PG-21 only)	POSITIVE
SYNC WIDTH	Clockwise

Set the oscilloscope sweep speed to 0.1 μ s/cm and vertical sensitivity to 5V/div. D.C. coupled. Centre trace.

5.3.5.

Pulse Output

Turn POWER switch on, checking for the sound of cooling fan and noting that red pilot lamp lights. A rectangular pulse approximately 5V amplitude, approximately 100nsec wide will appear on the screen. (The trigger controls of the oscilloscope may need adjustment.

Check AMPLITUDE control vernier, 10V maximum, 3V minimum on the 0-10db range. Repeat for negative.

Return AMPLITUDE vernier to midway position and check attenuator steps. Return to top range.

5.3.6.

Double Pulse Mode - Square Wave Mode.

Turn FREQUENCY control anticlockwise and switch to 1 - 10MHz. Now turn FREQUENCY vernier clockwise until one pulse appears at each end of the trace.

Switch to DP. Turn DELAY vernier anticlockwise until a second pulse appears after the first on the screen. Check that WIDTH vernier alters the width of all three pulses now on the screen. Now switch to SQ. WAVE and adjust oscilloscope time base and FREQUENCY vernier until one complete cycle appears.

Check symmetry control SYM allows you to vary the mark to space ratio $\pm 7\%$ of period. Return to DELAY (SP) mode.

5.3.7.

Manual Operation

Reset the instrument controls as follows:

GATE/SYNC/EXT	EXT
DELAY	0-0.2 μ s
Vernier	Clockwise
WIDTH	0.2-2msec
Vernier	Midway
SLOPE	+VE
NORMAL/COMPLEMENT	NORMAL
DP/DELAY (SP)	DELAY(SP)
AMPLITUDE	MAX
POLARITY (PG-21 only)	POSITIVE

Set the oscilloscope time-base to 1msec/cm and operate the MANUAL button. A single pulse will appear at the output whenever the MANUAL button is pressed.

5.3.8.

External Trigger

Connect a square-wave source of approximately 1KHz, 2V amplitude (such as scope calibrator output) to the INPUT socket. With the controls set as above, connect the oscilloscope external trigger socket to the square-wave source using a tee-connector. Adjust for a stable display. A pulse will appear at the output of the pulse generator at the external source rate which will shift one half of an external signal period when the SLOPE switch is operated. The threshold potentiometer (marked T) may need slight adjustment for this check.

5.3.9.

Gated Operation

Retain the set up of 5.3.8. Set the instrument controls as follows:

FREQUENCY	1-10KHz
Vernier	Clockwise
DELAY	0-0.2 μ s
Vernier	Clockwise
WIDTH	20-2 μ s
Vernier	Anticlockwise
GATE/SYNC/EXT	GATE
SLOPE	+VE
DP/DELAY(SP)	DELAY(SP)
SYNC WIDTH	Clockwise
AMPLITUDE	0-10db
Vernier	Midway
POLARITY (PG-21 only)	POSITIVE
NORMAL/COMPLEMENT	NORMAL

Apply a 1KHz square-wave of greater than 1V peak amplitude to the EXT input socket as in 5.3.8. A group of pulses will appear followed by a space. Group and space are interchangeable by the operation of the SLOPE switch.

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SECTION 6
CIRCUIT DESCRIPTION

For ease of construction and maintenance the bulk of the electronic circuits are mounted on separate printed circuit as follows:

	<u>RATE GEN'R</u>	<u>WIDTH/DELAY</u>	<u>OUTPUT</u>	<u>POWER</u>	<u>OUTPUT/DRIVER</u>
PG-21	21/1	21/2	21/2	23/4	21/5
PG-23	21/1	21/2	23/3	23/4	NIL

6.1. INPUT CIRCUIT AND RATE GENERATOR

The input and rate generating section (fig.7.3.) consists of a Schmitt trigger and free-running multivibrators which are used to provide the basic pulse or square waves required to drive the width/delay section. When the instrument is operated in its EXT mode, the input frequency fed via the Schmitt circuit determines the rate of operation of the generator. If the GATE or SYNC mode is selected, the free-running multivibrator determines the repetition rate, which can be 'pulled' by an external input (if present) in the SYNC mode and 'interrupted' in the GATE mode. The rate generating circuitry is housed on card 21/1 and provides four outputs, comprising a square wave derived directly from the free-running multivibrator which is capable of symmetry adjustment, and three further outputs which are used to drive the width, delay and sync pulse generators on the following card. One of these outputs may be inhibited by operating the single/double pulse detector switch so that the width generator on card 21/2 can be driven either once or twice during each block period.

Referring to the circuit diagram of card 21/1 (fig.7.3.) it can be seen that Q1 and Q3 form the external input Schmitt trigger, the input signals being applied to pin 1. D1 and D2 act as input protection clamps. The manual control push button operates into pin 2 and its position in the circuit gives the system a manual gate facility as well as single shot operation. Threshold may be adjusted between $\pm 2V$.

Sensitivity is fixed at 1V peak on type PG-23 and variable 1-2V on type PG-21 via the trimpot connected to P4.

Q4 and Q5 form the slope selection inverters and their outputs are routed via the selector to either the rate generator itself when SYNC or GATE mode are selected or to the output drivers when 'EXT' is selected.

Q6 and Q13 form the rate generator, Q9 and Q10 being variable current sources providing vernier control in the pulse mode and symmetry adjustment for square wave operation.

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Q8 inhibits the clock either for the duration of a differentiated Schmitt trigger output during SYNC operation, or for the duration of the gating waveform when the GATE mode of operation is selected. Q11 is a 'kicker' which monitors both phases of the rate generator and ensures clock starting under all conditions.

Q14 is an output driver which drives Q15 for pulse modes and provides output at pin 22 during square wave operation of the instrument.

Q15 and Q16 form an OR function, accepting either the rate generator signals or the external signals via the Schmitt and selector switch into pin 23. The output of the OR gate drives the three current sources providing outputs to the next card of which Q17 is inhibited by +12V to pin 13 from the pulse mode switch during single pulse operation.

6.2.

WIDTH/DELAY GENERATOR

The pulse width, delay and sync output sections are housed on card 21/2 (Fig.7.5.) and contain three monostable multivibrators. The first of these forms the delay generator which is triggered once per clock period, an output being derived from the back edge of its output waveform, which in turn triggers the width generator in the single pulse mode. During double pulse operation, the width generator accepts a second trigger per period derived directly from the rate generator (Q17) and which is not delayed so that two pulses for each clock period appear at the output of the width monostable.

The third monostable circuit is the sync pulse generator which gives an output of variable width into 50 ohms. During single pulse operation the input of the sync pulse generator is delayed by 90ns by means of a fixed delay line enabling the output pulse delay to be set negative with respect to the sync pulse output. During double pulse operation the delay line is switched out so that the first pulse of each pair is coincident within 5ns of the sync pulse output. The three monostable circuits are similar. Referring to circuit 21/2 it can be seen that Q1 and Q2 form a fast trigger generator, producing pulses of 5V amplitude and some 15ns duration. The trigger pulses are applied to emitter follower Q5 and via the timing capacitor C7 to Q4. This stage turns off and variable current source Q3 produces a linear discharge of the timing capacitor, providing vernier control. Q6 provides the inversion necessary to complete the loop and the output of the monostable appears at its collector. Q7 inverts the pulse and shapes it to drive the fast trigger generator Q8, Q9. During double pulse operation an identical trigger circuit Q10, Q11, receives input from the rate generator card, the two triggers being mixed at the collectors of Q11 and Q9 and fed to the width generator Q12 to Q15, which is identical to the delay generator described above. The output of Q15 drives the grounded base amplifier Q16 used to provide output signals to the next card via pin 13.

The sync pulse generator consists of the standard trigger circuit Q17, Q18 followed by a single range variable monostable Q19 to Q21 providing sync pulse width variation. C24 is the timing capacitor and varying voltage applied via pin 15 to R46.

6.3.

OUTPUT STAGE.

6.3.1.

Output Stage - PG21

The output circuitry of the PG-21 is fitted on two separate circuit boards PG-21/5 (figs.7.10, 7.11) and PG-21/3 (Figs.7.8, 7.9).

PG-21/5 is common to both output channels and provides the facilities for Normal/ Complement and Polarity changeover.

PG-21/3 is the output stage proper and comprises two channels which are essentially mirror images of one another in terms of transistor types.

Q1 and Q2 form a differential switch providing anti-phase outputs from the common input at P1. The outputs from Q1, Q2 collectors are connected via gates Q3 and Q4 respectively which feed the base of Q5, the first stage of level shifting in the output chain. Q3 and Q4 are controlled by the Normal/Complement or Polarity switches to provide the necessary drive for the output selected. D1, D2 and D3, D4 supply ± 13 volts to the second amplifier on 21/3 circuit board.

PG-21/3 Output Board

Considering the positive channel only, Q1 provides a second stage of level shifting feeding the first current pair Q2, Q3. Further amplification is carried out in Q4, Q5 to drive the compound emitter followers Q6 and Q7. Finally Q8, Q9, and Q10 are emitter followers feeding the output termination via the channel selector relay and output attenuator.

The only adjustment provided on the output stage is RV1 controlling the emitters of Q4, Q5. This allows adjustment of pulse shape within certain limits and should be set for optimum rise/time and overshoot.

Short circuit protection is achieved by including resistors in the collector circuits of Q8, Q9 and Q10 which saturate when the output is shorted and the ± 16 V supplies switch to the constant current mode.

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Figure 1. Schematic representation of the experimental design. The subjects were divided into two groups: the control group (C) and the experimental group (E). The control group (C) was divided into two subgroups: the control group (C) and the control group (C). The experimental group (E) was divided into two subgroups: the experimental group (E) and the experimental group (E). The control group (C) was divided into two subgroups: the control group (C) and the control group (C). The experimental group (E) was divided into two subgroups: the experimental group (E) and the experimental group (E).

TABLE 1									
Summary of the results of the 1997-1998 survey of the health status of the population of the Republic of Serbia									
Age group		Sex		Marital status		Education		Occupation	
Age	Sex	Marital status	Education	Occupation	Age	Sex	Marital status	Education	Occupation
15-19	M	Married	Primary	Unemployed	20-24	F	Married	Primary	Unemployed
20-24	M	Married	Primary	Unemployed	25-29	F	Married	Primary	Unemployed
25-29	M	Married	Primary	Unemployed	30-34	F	Married	Primary	Unemployed
30-34	M	Married	Primary	Unemployed	35-39	F	Married	Primary	Unemployed
35-39	M	Married	Primary	Unemployed	40-44	F	Married	Primary	Unemployed
40-44	M	Married	Primary	Unemployed	45-49	F	Married	Primary	Unemployed
45-49	M	Married	Primary	Unemployed	50-54	F	Married	Primary	Unemployed
50-54	M	Married	Primary	Unemployed	55-59	F	Married	Primary	Unemployed
55-59	M	Married	Primary	Unemployed	60-64	F	Married	Primary	Unemployed
60-64	M	Married	Primary	Unemployed	65-69	F	Married	Primary	Unemployed
65-69	M	Married	Primary	Unemployed	70-74	F	Married	Primary	Unemployed
70-74	M	Married	Primary	Unemployed	75-79	F	Married	Primary	Unemployed
75-79	M	Married	Primary	Unemployed	80-84	F	Married	Primary	Unemployed
80-84	M	Married	Primary	Unemployed	85-89	F	Married	Primary	Unemployed
85-89	M	Married	Primary	Unemployed	90-94	F	Married	Primary	Unemployed
90-94	M	Married	Primary	Unemployed	95-99	F	Married	Primary	Unemployed
95-99	M	Married	Primary	Unemployed	100+	F	Married	Primary	Unemployed

Open circuit protection is provided by the reverse Vbc of the output devices and the attenuator circuit.

6.3.2.

Output Stage - PG-23

The output circuitry of the PG-23 (Fig.7.7) consists of two channels which are mirror images in terms of semiconductor types. After Normal/Complement switching the pulse undergoes further stages of level shifting and amplification until sufficient swing is available to obtain the required 10V in 50 ohms. In the positive output channel Q1, Q2 form a current pair and Q3, Q4 are a pair of grounded base stages. Normal/complement switching is carried out by inhibiting either Q3 or Q4 by means of 12V applied to P1 or P2. The output of Q3 or Q4 is level shifted by Q5 Q6 and amplified by Q7 Q8, which then drive the final output switch Q9 Q10. This has a collector supply set at two diode drops below the +16V line, ensuring that when Q10 is off sufficient headroom is left for the emitter follower stages Q11 to Q15 which drive the output termination.

The negative pulse channel is very similar and is essentially a mirror image of the positive channel.

Output stage short circuit protection is provided by resistors in the collectors of the output emitter followers which ensure saturation when the output is shorted, and by making the +16V supplies go into a constant current mode when a short is applied.

Open circuit protection is inherent in the reverse Vbe of the output devices and the attenuator values.

6.3.3.

Output Attenuators

The output from the positive or negative channel is taken to a passive attenuator comprising four 10db steps and a continuously variable 3:1 vernier and thence to the BNC output connector.

As can be seen, the source impedance is not 50 ohms and the instrument therefore relies on good output termination for a clean pulse waveform.

POWER SUPPLIES

The power supply consists of a mains transformer followed by full wave diode bridge rectifiers driving reservoir capacitors and regulator amplifiers. The low current power supply components are mounted on printed circuit card 23/4, the series transistors are on a heatsink which is in the cooling fan airflow. The printed circuit board is hinged and can be swung out for ease of measurement and servicing and the power supply outputs are accessible on the emitter pins of the power transistors.

The power supplies are protected against accidental short circuit and care has been taken to ensure reliable operation at high ambient temperatures. From circuit diagram 23/4 (Fig.7.9.) it can be seen that Q1 is the series element for the -7V line which is referenced by means of Zener D5. The -16V line uses D8 as reference, Q4 being the voltage amplifier and Q3 and Q5 supply the output current. Q2 with associated components is a current source ensuring high gain of amplifier Q4 and R5 is an output current sensor which together with D6, D7 determine the point at which the supply becomes a constant current source.

The other supplies are very similar, differing mainly in polarities of voltage supplied. Care is taken to ensure self protection of the power supplies by ensuring saturation of the $\pm 7V$ series elements and by allowing the $\pm 16V$ lines to run into a constant current mode when excess current is drawn. This also limits the amount of current supplied to the output stages which are fairly symmetrically connected between the supplies, making it easy to provide versions of the instrument giving either dual positive or dual negative output pulses.

SECTION 7

MAINTENANCE - DIAGRAMS

7.1.

WARRANTY

Lyons Instruments Limited guarantees each instrument manufactured by us to be free from defects in material and workmanship for a period of one year from date of delivery to the original purchaser. Repair during this time will be made by us free of charge if the instrument is returned to our works carriage paid.

Excluded from this guarantee are valve replacement, as well as all damage caused by, or related to, abuse of the instrument either electrically or mechanically. In this case repairs will be charged at cost and an estimate will be submitted for approval before the work is started. Output stage transistor replacement, if required, is not normally included in the terms of the guarantee.

If an instrument is believed to be defective, please notify our Service Department, giving the model and serial number of the instrument, as well as a description of the nature of the fault. Our Service Department will then, if necessary, authorise the return of the instrument under the terms of this guarantee and advise how shipment should be made.

7.1.1. Claim for Damage in Shipment.

If, on receipt, the shipping cartons show evidence of rough treatment, entry should be made on the carrier's delivery receipt indicating this condition.

As each instrument is unpacked, it should be inspected to ascertain that no damage has occurred during shipment. If no damage is visible, operational checks should be performed to make sure that the instrument is in its original operating condition. If any damage is revealed, a claim should be filed immediately with the carrier, stating the extent of the damage. A copy of this report should be forwarded to Lyons Instruments together with the model and serial number of the instrument. We will then advise how the instrument should be returned for repair or replacement.

7.1.2. Shipping Instructions For Returning Instruments under Guarantee

No instrument should be returned to the factory without prior authorisation from Lyons Instruments Limited. Shipping instructions will be given at the time return of an instrument is authorised. In all cases, the instrument should be packed in a strong container and surrounded by adequate shock-absorbing material.

Transit insurance covering the instruments being returned to Lyons Instruments should be effected by the sender.

7.2.

ROUTINE MAINTENANCE

The instrument is fan cooled and when used in dusty environments the side filter plates should be removed (4 retaining screws) at 6 monthly intervals and washed in detergent. Replace when dry. In very hot conditions, the fan motor may require oil at 12 monthly intervals: remove instrument top cover and place no more than two drops of light oil onto the top bearing inner sponge.

7.3.

CALIBRATION

The instrument has been designed to have a minimum of internal adjustments. The frequency, width and delay controls have ranges considerably in excess of the 10 to 1 requirements and therefore there is no need for upper and lower limit range settings. The remaining potentiometers are concerned with power supply settings and output stage 'on' currents and should require adjustment at twelve monthly intervals or after any necessary repair work. Details of the adjustments are as follows:-

7.3.1

7.3.1. Power Supplies

Set controls to COMPLEMENT and select EXT on the lever switch. Terminate output(s) in 50 ohms at maximum amplitude and monitor the outputs of the power supplies. This can be done on the heatsink measuring at the emitter pins of the Series stabilisers.

The levels are as follows, measured relative to chassis:

YELLOW	+16V Adjust (RV2 on 23/4 to $\pm 3\%$ (AVO8) Ripple	3mV p-p
BLUE	-16V Adjust (RV1 on 23/4 to $\pm 3\%$ (AVO8) Ripple	3mV p-p
RED	+12.5V $\pm 0.5V$	Ripple 2mV p-p
GREEN	-7V $\pm 0.5V$	Ripple 5mV p-p
ORANGE	+7V $\pm 0.5V$	Ripple 5mV p-p

Note: On earlier instruments RV1 and RV2 were not included and the power supplies were adjusted on test. The first two adjustments need not therefore be carried out.

7.3.2. Output Stage

Set controls to NORMAL, select EXT on the lever switch. Measure at the collector of Q10 on 23/3 Adjust RV1 on 23/3 to between -1 and -2V (must not be more positive than -1V). Measure at the collector of Q25 on 23/3. Set RV2 on that board for collector level of +1 to +2V (must not be more negative than +1V).

N.B. These adjustments should not **normally** be attempted unless specific problems exist in either the power supplies or the output circuits.

Should you experience any difficulties the Engineering Staff of L.I. are always at your service.

7.4.

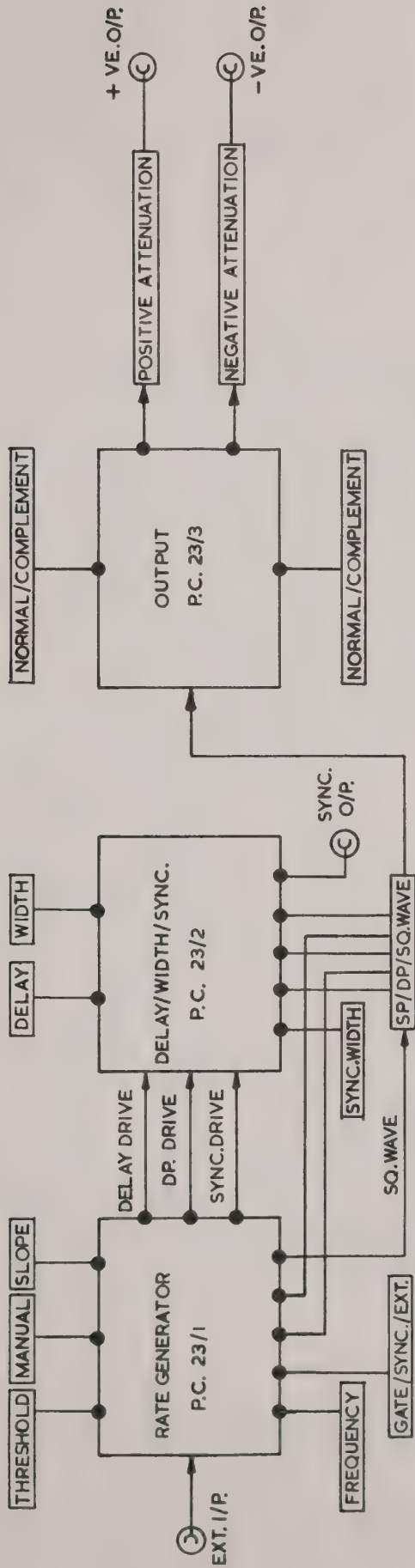
DIAGRAMS

The following figures are appended:

- | | |
|-----------|--------------------------------------|
| Fig. 7.1. | Block Schematic |
| Fig. 7.2. | Rate Generator.- Component Layout |
| Fig. 7.3. | Rate Generator - Circuit Diagram |
| Fig. 7.4. | Width/Delay Board - Component Layout |
| Fig. 7.5. | Width/Delay Board - Circuit Diagram |
| Fig. 7.6. | Output Board - Component Layout |
| Fig. 7.7. | Output Board - Circuit Diagram |
| Fig. 7.8. | Power Supply - Component Layout |
| Fig. 7.9. | Power Supply - Circuit Diagram |

PG-21 Only

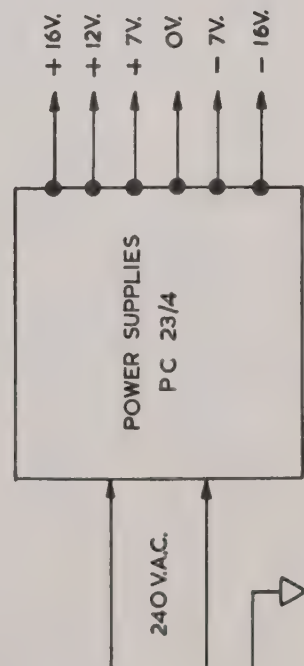
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| Fig. 7.10. | Output Driver Board - Component Layout. |
| Fig. 7.11. | Output Driver Board - Circuit Diagram. |



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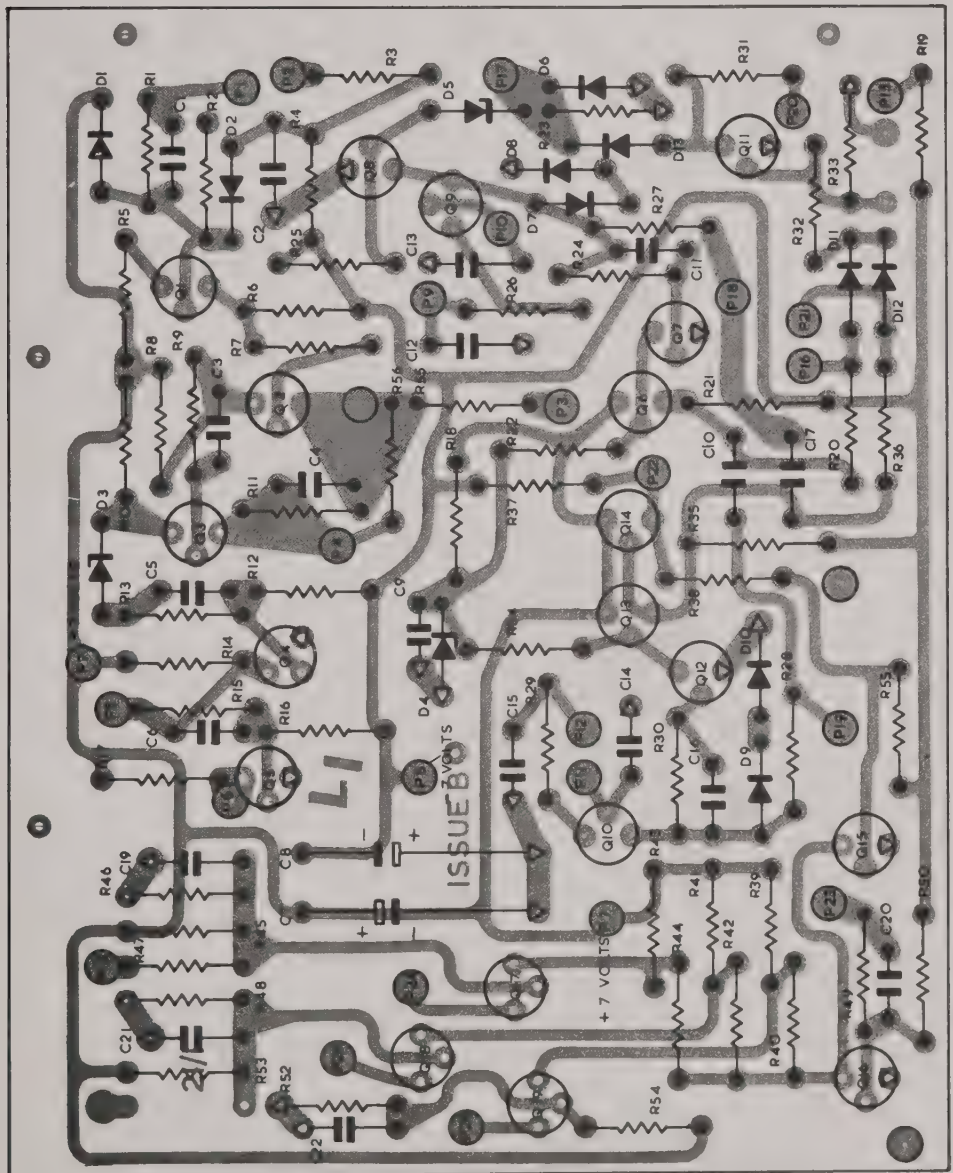
FIG. 7.1

BLOCK SCHEMATIC FOR PG.23

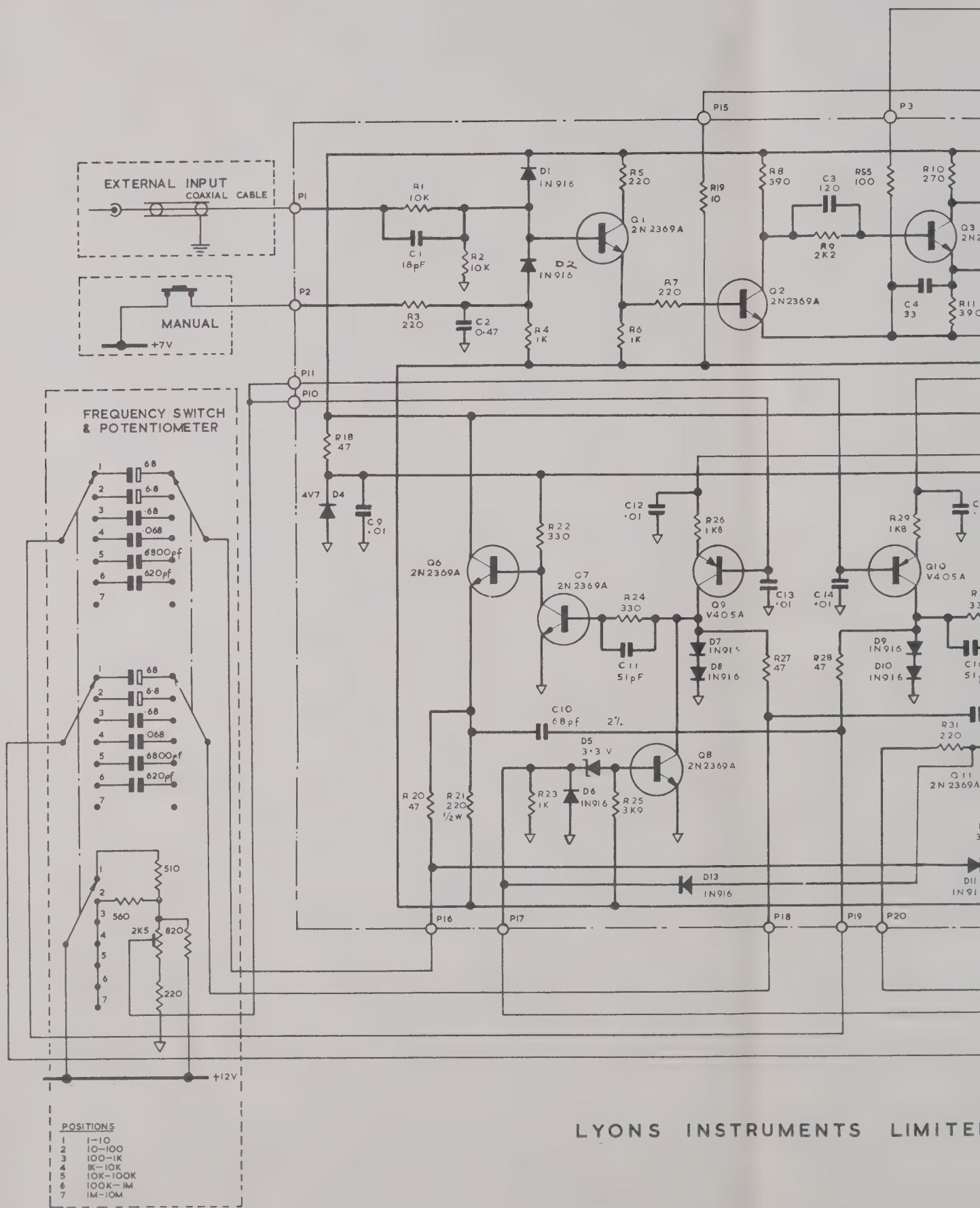


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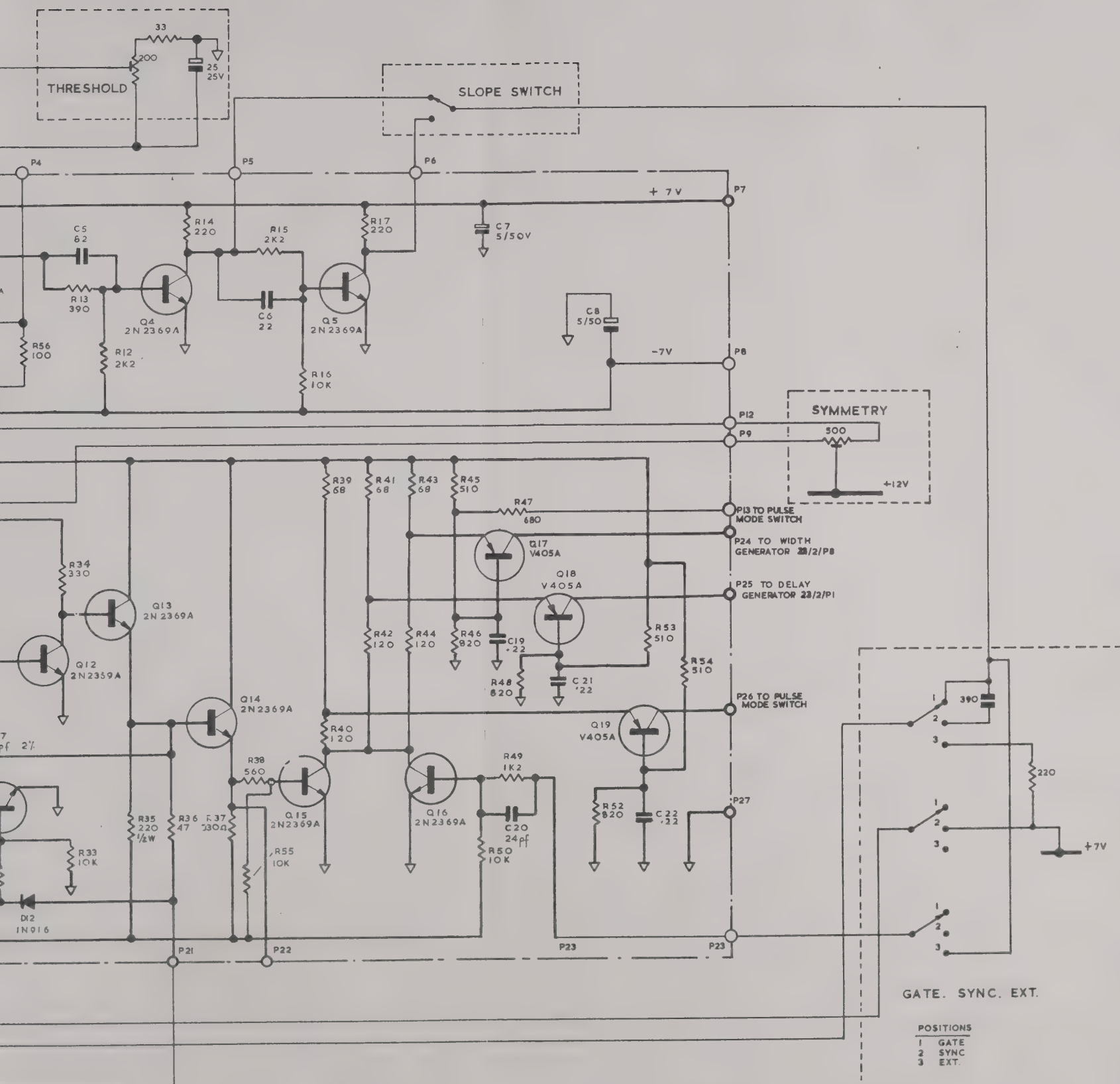
FIG. 7.2



23/1 PRINTED CIRCUIT BOARD
COMPONENT LAYOUT VIEWED
ON COPPER TRACK SIDE (B)



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NOTES
UNLESS OTHERWISE STATED
ALL RESISTOR VALUES IN OHMS & ARE 1/4 WATT
ALL CAPACITOR VALUES IN MFD

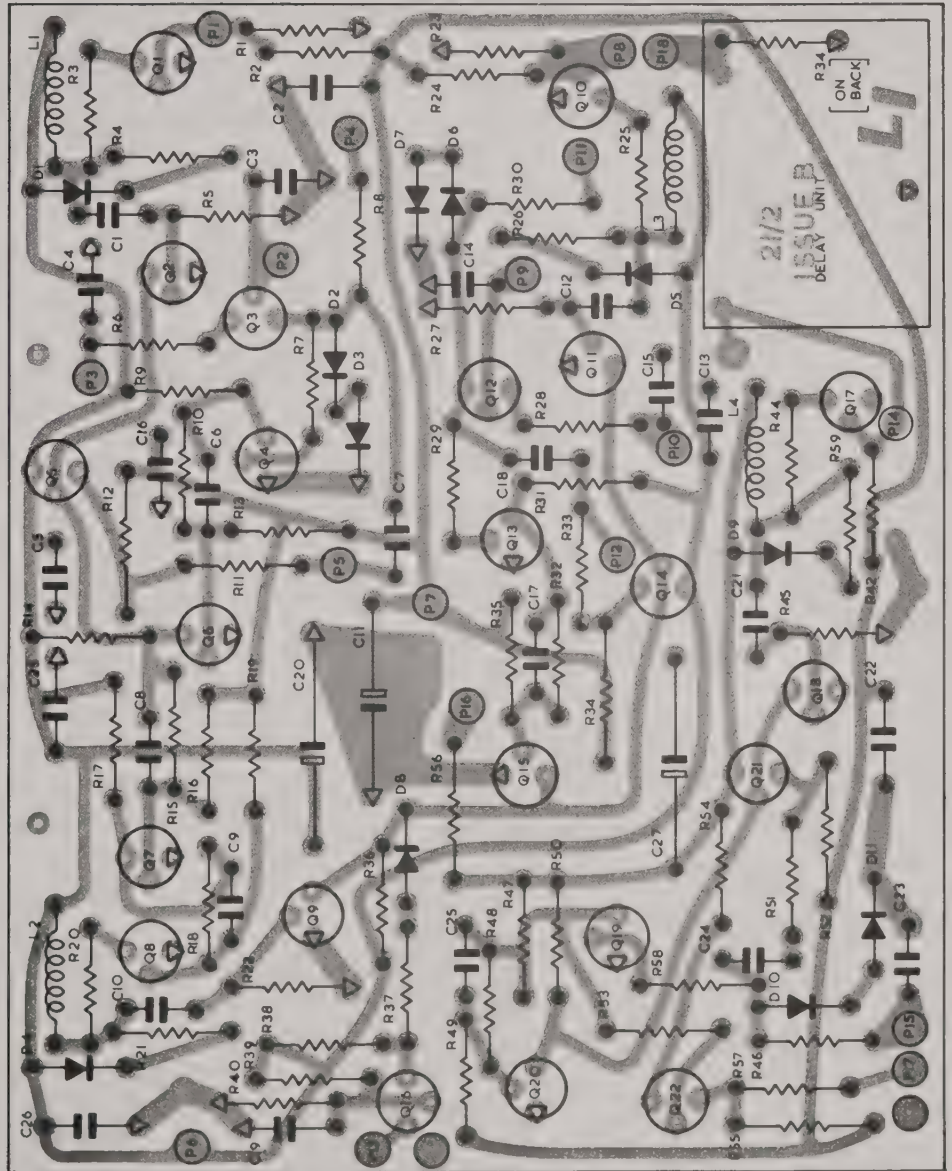
RATE GENERATOR

23/1 P.C. BOARD CIRCUIT DIAGRAM (B)

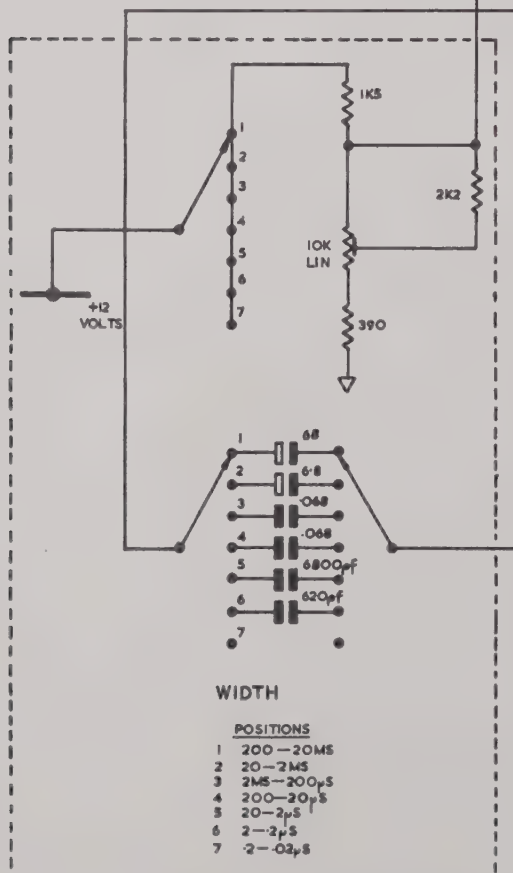
FIG. 7.3

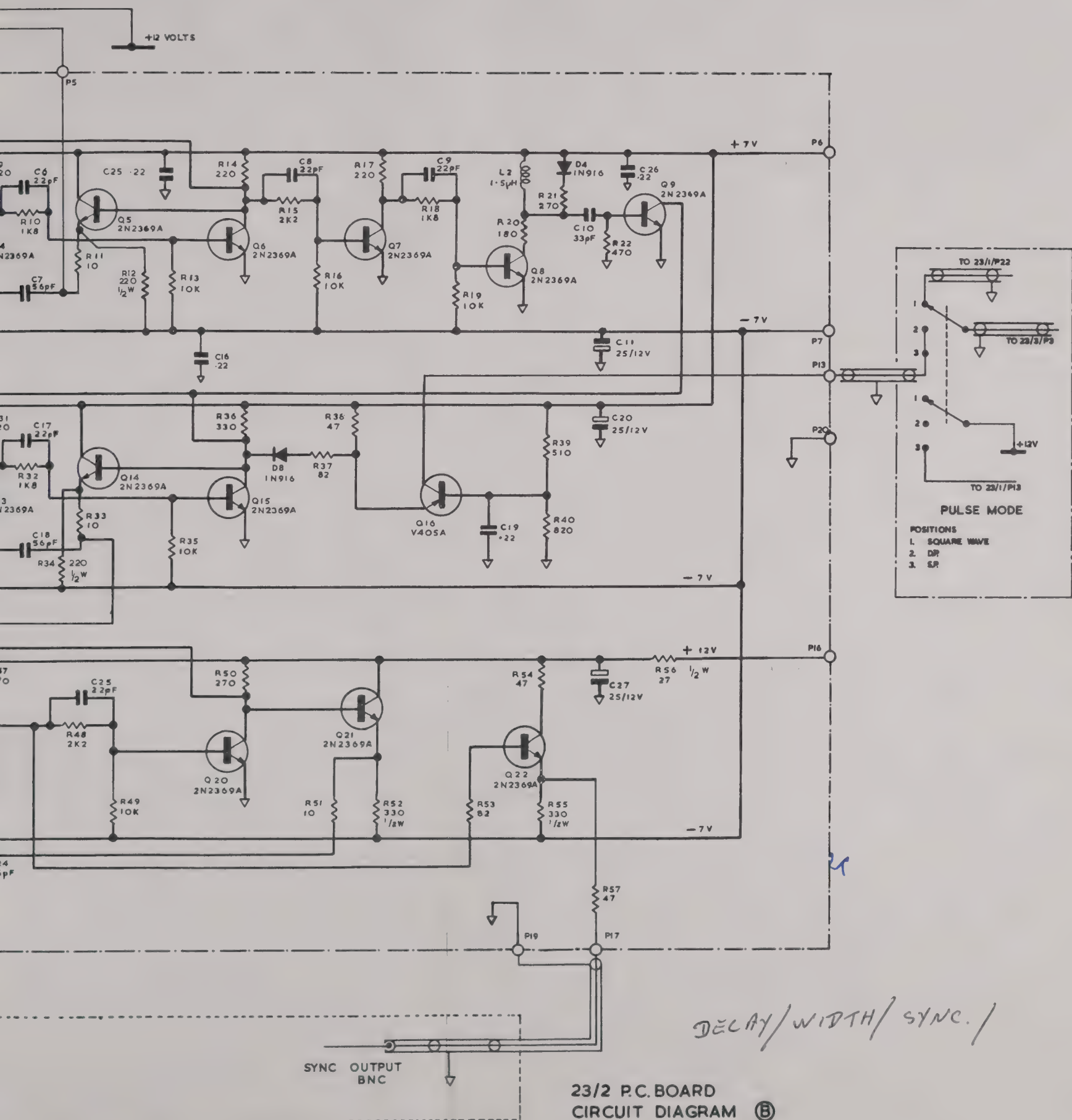
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FIG. 7.4



23/2 PRINTED CIRCUIT BOARD
COMPONENT ASSEMBLY VIEWED
ON COPPER TRACK SIDE (B)





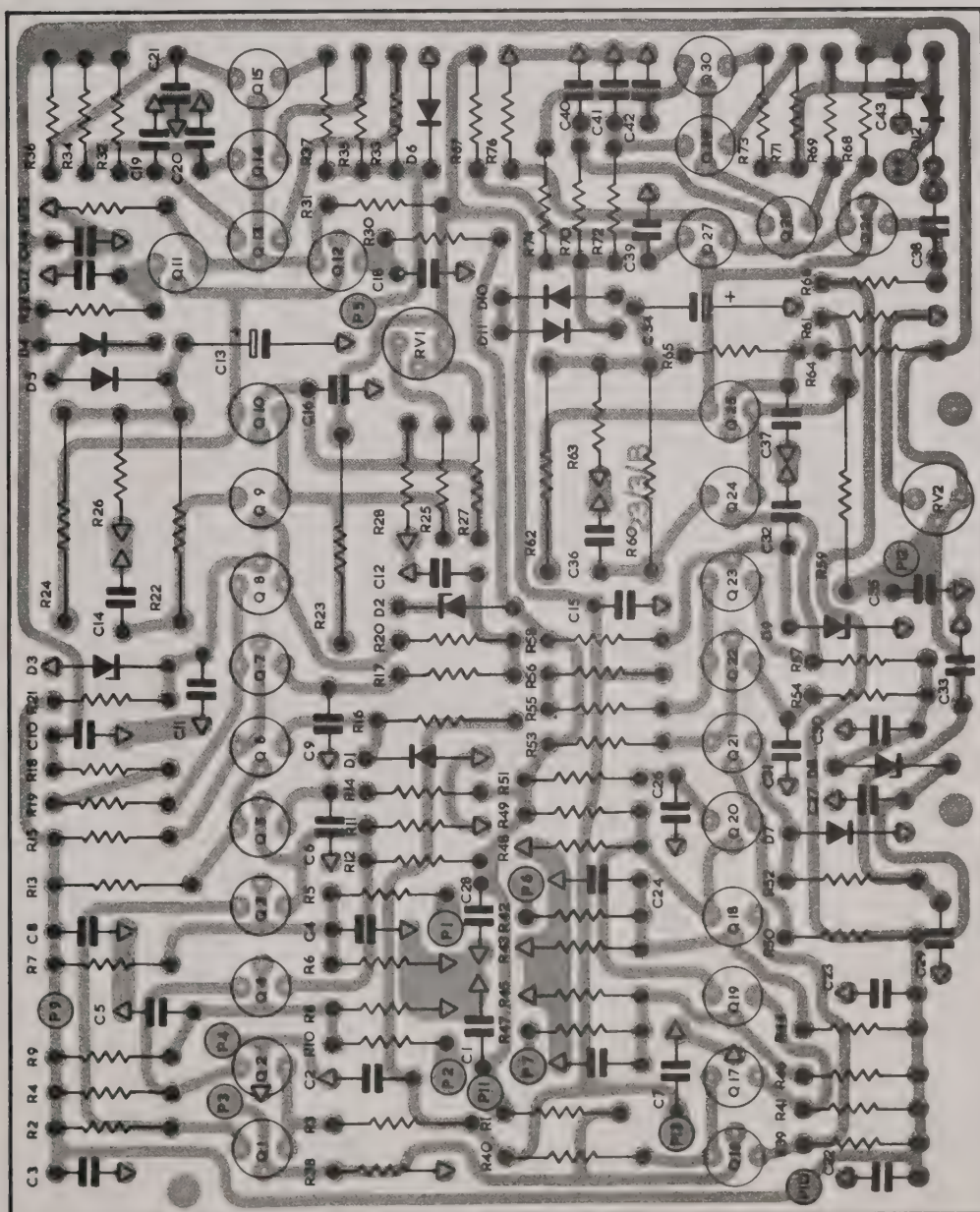
NOTES

UNLESS OTHERWISE STATED OTHERWISE
ALL RESISTOR VALUES IN OHMS & ARE 1/4 WATT
ALL CAPACITOR VALUES IN MFD

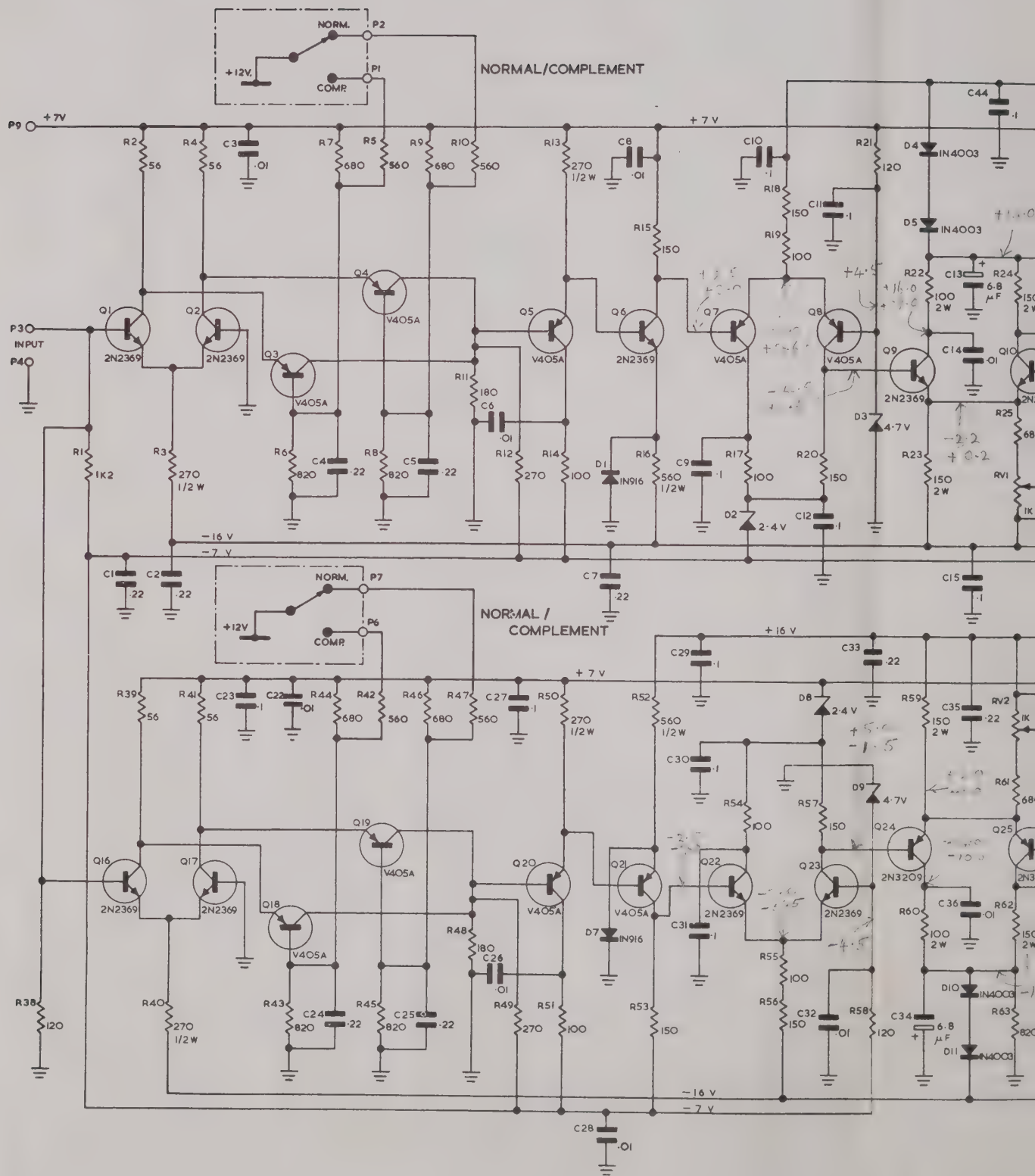
FIG. 7-5

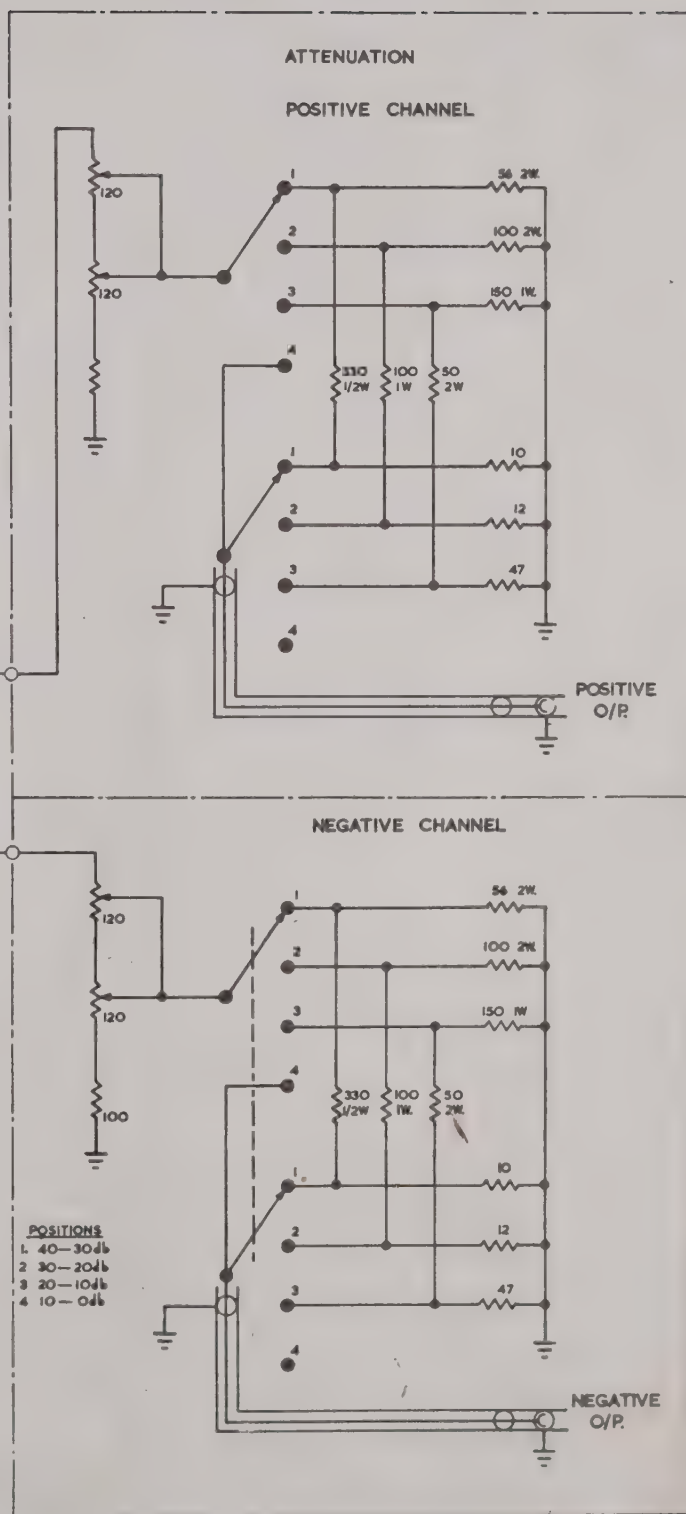
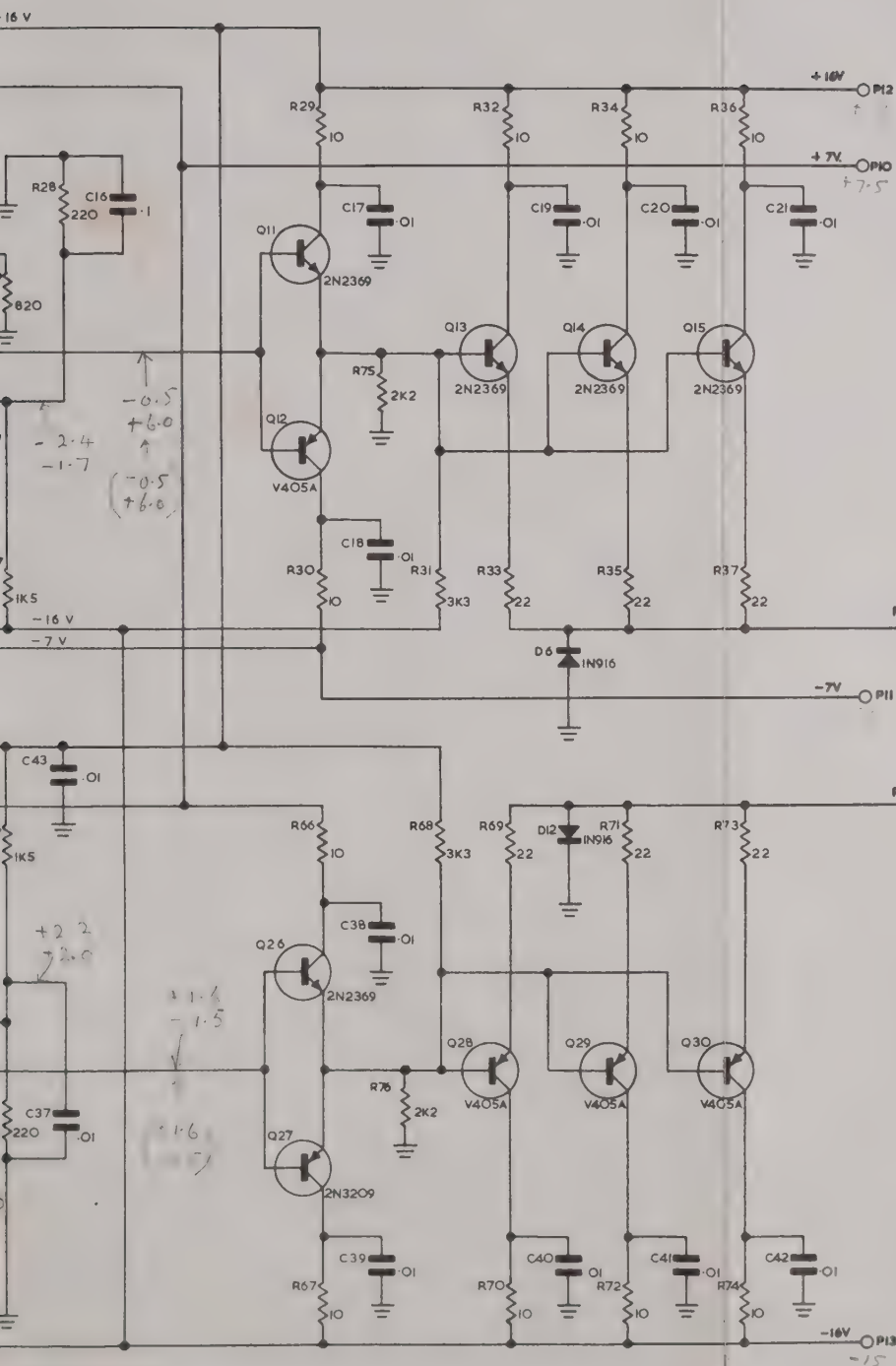
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FIG. 7.6



COMPONENT LAYOUT FOR 23/3/B P.C.BOARD
VIEW FROM TRACK SIDE





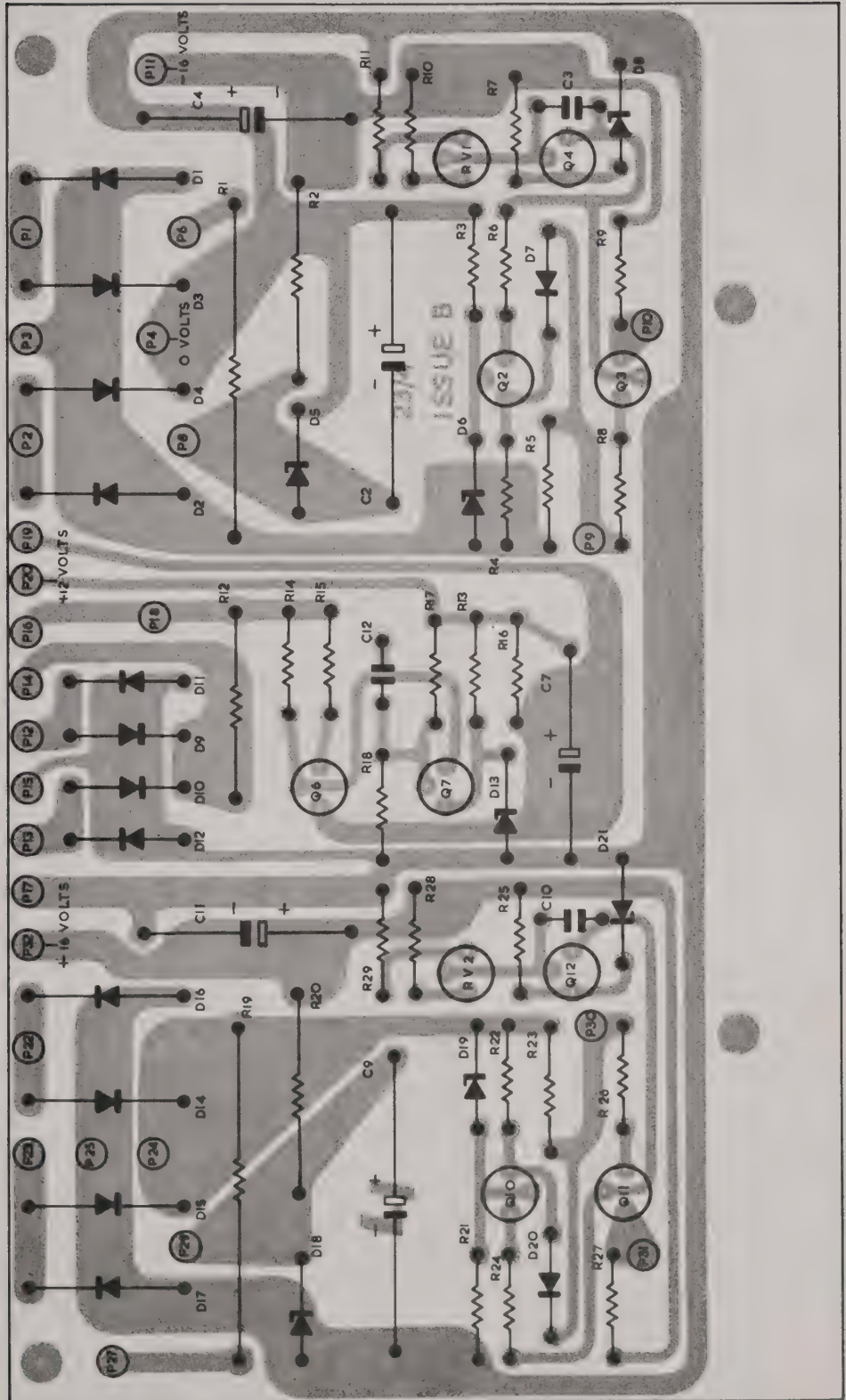
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NOTES.
UNLESS STATED OTHERWISE:-
ALL RESISTOR VALUES IN OHMS AT 1/4W.
ALL CAPACITOR VALUES IN MPD.
ALL CIRCUITRY WITHIN DOTTED LINES
NOT ON P.C. BOARD.

23/3 P.C. BOARD CIRCUIT DIAGRAM

FIG. 7.7

FIG. 7.8



23/4 PRINTED CIRCUIT BOARD
COMPONENT LAYOUT VIEWED
ON COPPER TRACK SIDE (B)

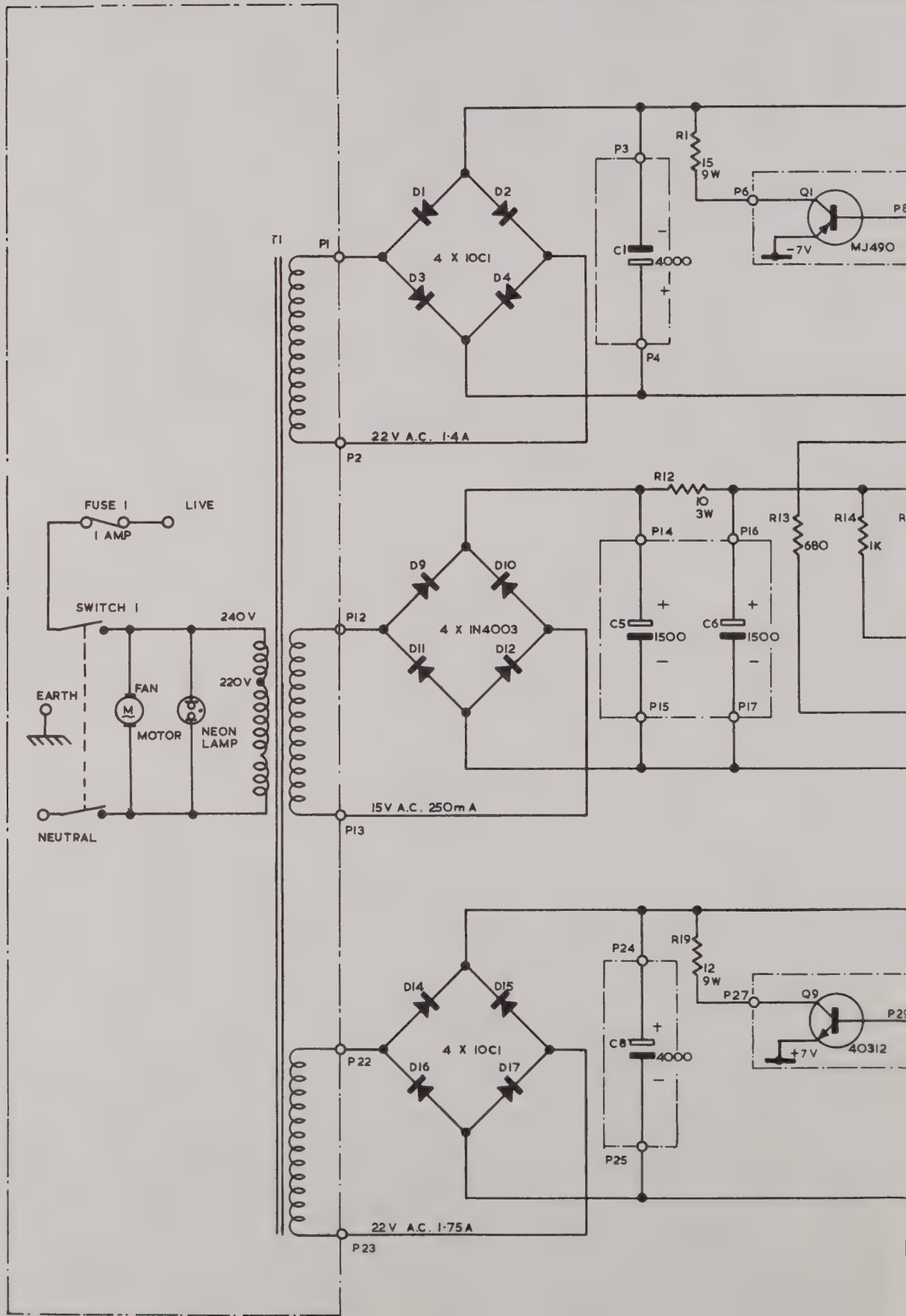
NOTES

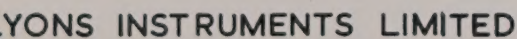
RESISTORS

ALL VALUES IN OHMS UNLESS STATED OTHERWISE

CAPACITORS

ALL VALUES IN MFD. UNLESS STATED OTHERWISE





POWER SUPPLY
P.C. BOARD 23/4 CIRCUIT

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